

# Fax Cover Sheet

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May 31, 2000

Donna Wieting, Chief  
Marine Mammal Conservation Division  
Office of Protected Resources  
National Marine Fisheries Service  
1315 East-West Highway  
Silver Spring, MD 20910-3226.

Fax 301-713-0376

Dear Ms. Wieting:

In the Spirit of Aloha,

these comments on the Navy LFAS project demand the following:

1) The Navy's application for a "small take" permit must be summarily rejected as totally absurd. **Restore the quiet and sanctity of our planet's oceans! Pull the plug on LFAS. Stop the racket!**

2) The Navy's LFAS FEIS is fatally flawed by its bias, poor science, and its ridiculous extrapolations from limited and absent data demonstrate our massive ignorance of the many marine species in their environment, and LFAS's effects on them. Based on this document alone, **the NMFS must reject the Navy's application for a "small take" permit and demand a totally new or supplemental EIS.**

3) I conclude that the basis of the Navy LFAS FEIS is a "reverse engineering" attempt to justify primarily the 180dB level of sound as "safe" despite much accepted evidence to the contrary. This is the opposite of science. Were the NMFS to grant the Navy's request, this criterion would be applied to all future applications, giving the Navy carte blanche to continue in their decimation of the ocean's creatures with many other systems that will come up for approval in the future.

In this sense, the LFAS project is a "red herring" to distract NMFS and the people of America from the totality of the change in naval warfare now underway. The LFAS is merely the start of a "sea change" in the nature of warfare, a harbinger of even more lethal systems that the Navy will seek to deploy in the future. **Close this barn door now while we still have reasonably intact oceans and the Whales, Dolphins and fish are still alive.**

4) Applying the "precautionary principle" to the demonstrated and possible harm of the LFAS technology, its testing and deployment must be rejected. The burden of proof is on the Navy to prove that LFAS is safe. This they have utterly failed to do. Therefore, the permit for a "small take" must be rejected until such proof is provided. Given this, NMFS lacks the data to conclude that LFAS will have a "negligible impact" on the planet. **Again, on this basis alone, the Navy's permit application must be rejected.**

5) The existence of significant new data and results especially concerning resonance effects of LFAS on lungs, sinuses, ears, fish bladders, and other structures, yet to be considered in any meaningful way by the current FEIS, and the implications of the novel forms of damage that this new data suggests that LFAS may cause **REQUIRES** the NMFS to demand a new or supplemental EIS that takes this data into account.

The Navy has the capability and resources to conduct a thorough review and modeling of all this data, including, for example, full finite element analysis models of the response of the ears and air spaces of the Cetacea and other marine mammals to LFAS sounds to assess the potential for tissue damage, hearing loss, and death.

New empirical experiments must be done to assess the implications for the oceans as a whole and the creatures that live in them, and the effects on ecosystem performance, productivity, biodiversity, extinction rates, and numerous other factors. **Thus the current permit application must be rejected pending proper analysis and research incorporating this new data showing clearly that LFAS is safe for our planet.**

6) New data, yet to be address by the Navy, or NMFS, or the current Marine Mammal Protection act, or the Endangered Species Act have arisen during this comment period. These data demonstrate:

- a) the **self-awareness** of the Cetacea, as demonstrated by recent "mirror" experiments.
- b) **Cultural transmission** of information across generations by Cetacea, eg. whalesong
- c) further evidence of **language and communication** skills including **tool use** such as computer use by Dr. Ken Marton and language skills demonstrated by Dr. Louis Herman (expanding on the pioneering work of Dr. John C. Lilly, Dr. Hank Truby, Dr. Wayne Batteau and Dr. Patrick Flanagan) as well as the evidences of the Cetacea having their own language and syntax by Markov and Ostrakaya)
- d) New data showing their **lifespans** are some **200** years, making them the longest lived of all creatures
- e) Growing appreciation that with their sonic and other skills they are able to heal diseases and various neurological conditions in humans that are **beyond the ability of current human medicine**, eg. Dolphin Assisted Therapy (DAT). (See, e.g. the works of Dr. Steven Birch, Dr. Robert Nathanson, Dr. Hank Truby, Dr. Betsy Smith, David Cole, and the Proceedings of the First and Second International Conferences on

Dolphin Assisted Therapy, as well as a large and growing number of reports by people testifying to such results from their personal interactions with the Cetacea)

f) Growing appreciation that Dolphin Assisted Underwater Births lead to increased wellbeing of our children, including such benefits such as **more rapid and superior early development, increased brain size, and increased IQ.** (See the works of eg. Igor Tcharkofsky, Dr. Michel Odent, Dr. Gowri Motha, and Estelle Meyers, et alia)

g) the Cetacea possess the **largest and oldest brains** on the planet, exceeding our own in size, intelligence, capability, and cultural history; in fact, the Cetacea have had superior brains and abilities **for several times longer than our entire evolutionary history** as the genus Homo ... for some 15 to 30 million years.

g) Our renewed and expanded appreciation of the Cetacea leads me to the conclusion that **they are more intelligent than humans**, and the fact of their culture and cultural transmission of knowledge across generations shows us that they are and have been a multi-species culture of the greatest antiquity.

h) The trait of self-awareness, shared only with humans and the great apes, places the Cetacea in a similar category to humans. In fact, as stated in resolutions now enacted by cities and counties in the United States, they are *"living cultural resources"* inhabiting 3/4 of the Earth's surface.

i) **Given the above, the Cetacea are now seen to be similar to or superior to human beings in all major traits that we have used to define our own species as a people, and that all these traits are shared by the Cetacea.**

j) The Cetacea's scientifically demonstrated capabilities and traits puts them in a unique category, yet to be reflected in current legislation. In fact, **the Cetacea are a sovereign people** entitled to recognition under our laws as the Cetacea Nation and as living cultural resources, as has been legislated by the City of Malibu, California. In this, the Cetacea now have a status similar to that of the Australian indigenous people, who were legally game animals until they gained their rights as human beings in 1967.

f) The knowledge and skills of the Cetacea are providing and will continue to provide new and novel benefits to humanity that will enrich the cultures of the world. Given our current state of ignorance of the Cetacea, the possibilities are indeed vast and open.

k) Therefore, the Marine Mammal Protection Act is deficient because it fails to include these new data. Therefore, it must be re-written to reflect our new knowledge of their status, sentience, awareness, intelligence, knowledge, and their cultural history, as well as the benefits to humanity that will be realized when they are properly recognized and honored for the awesome beings that they are.

l) The implications of the fact that the Cetacea are a people suggest that Cetacea matters be handled by the State Department and the United Nations, and that

appropriate treaties of cooperation and friendship be enacted by the American people, Congress and the other nations of Earth.

m) From this point of view, deaths of Cetacea cause by human activities such as LFAS, whaling, pollution and other insults are **genocide**. I suggest that humanity as a whole embrace this new view and begin a concerted effort to preserve, protect, and enhance the wellbeing of the Cetacea

7) Divers, swimmers and children in the water are at risk from LFAS which may already be having deleterious effects on coastal human communities. **The sum total of demonstrated effects and plausibly predicted effects exceeds the "small-take" criterion and I therefore completely reject any conclusion of a "negligible effect" by NMFS.**

Besides the deaths of Cetacea, the effects could include changing the migration routes of birds that depend on sensing low-frequency sound for navigation and disrupt plankton and micro-organisms in the oceans. The damage that may occur can effect our very food supply by killing fish, disrupting ecosystems worldwide, reduce the biodiversity of the oceans and in the process endanger much of the life of the Earth, especially humans that may die when their food supply is reduced.

LFAS, should it effect the oxygen production of the oceans, may even damage the air we breathe. We at this point, must consider this and other effects of any system that will be implaced over 80% of the oceans, and will be deployed by many other nations as well. Should NMFS approve the Navy's application, it will thus give tacit approval to other nations efforts along the same lines.

8) The Navy has failed to include all relevant aspects of a total project in their FEIS. This is called "segmentation, and is against the law. Therefore, NMFS must reject the Navy's application until this is corrected. Specifically, the 4 LFAS test ships are only the start of a much larger testing and deployed system. The Navy has already cut contracts for 23 more LFAS vessels (Dr. Alex Leonard, personal communication). By limiting the FEIS to just the effects of 4 test ships while fully intending a to use 27 ships or more?" of the same type shows that they are guilty of segmentation to obscure the total effects of LFAS from the NMFS, the American people and Congress.

In fact, LFAS is part of a massive change in tactics and strategy which is underway as I write this. Part of this change is the creation of **supercavitation (SC) technology**, pioneered by the Russians, and presented in the current May 2001 issue of Scientific American. It shows that we now have rocket propelled torpedoes capable of 200 MPH+ speeds. It is rumored that the Kursk was sunk when a Skval ("Squall") torpedo malfunctioned. Already the Russians (our NATO allies?) have sold Skval's to China, Iran, and France, at least. They have also been selling Kilo Class diesel-electric submarines to nations like North Korea. These subs are super quiet since Toshiba released the means to make quiet propellers several years ago. With the addition of aluminum burning engines, or fuel cells, for example, these subs are much quieter than current nuclear subs and can have ranges like 4000+ miles. It is thought that the supercavitating technology, by which an underwater vehicle creates a shock wave at the nose of the vehicle, and then pumps gases from its rocket engines behind the shock wave to create a bubble around the whole vehicle. This reduces drag immensely, and may allow

hypersonic speeds underwater. With the addition of stealth technology, this may lead to hypersonic stealth submarines and other similar weapon systems.

One of the best ways to propel an underwater SC vehicle or torpedo is a detonation wave rocket engine. These were tested on torpedoes some 30 years ago by Jet Propulsion Laboratories. They had a specific impulse of between 800 and 1000 underwater.

I once was personally involved in the testing of two types of detonation wave engines in the air, and they are very loud. They make a rapid series of explosions that generate a nearly continuous series of shock waves. Since this is a likely method of propulsion for SC technology, I ask the NMFS to look into the possibility that the LFAS is a cover for such testing, especially in the Bahamas incident.

One reason I suspect this is the description of the damage to the whales in the Bahamas includes:

- Bleeding from the eyes
- Bleeding from the tissues surrounding the ears
- Bleeding behind the brain in the highly vascular *rete mirabile* that the Cetacea use to pump oxygen to the brain during dives
- Bleeding in the brain
- Bleeding in the cochlea.

While Dr. Lee Tepley and I, along with Ken Balcomb, Steven Birch, David Williams, and others have come to the conclusion that LFAS can certainly cause barotrauma through airspace resonances, and consequent ripping of tissues, it is curious that several of the areas of damage, like the eyes and brain, lack air spaces to resonate. So the question arises: ~~What exactly caused the damage to the whales in the Bahamas?~~

According to Dr. Ketten, an expert in Cetacean hearing and hearing damage whose expertise is acknowledged by the Navy, and who is performing the analysis of the damage to the whales that died in the Bahamas -- lists the kind of damage seen from shock and the Bahama whale deaths are consistent with **SHOCK WAVE DAMAGE**.

There are many possible sources of shock wave damage. The most direct is simply a large bomb explosion in the water. They generate lethal shock waves out to various ranges depending on their size.

Yet another cause is that the whales came too close to the sonars being used. At very close ranges, the high intensities of sound could simply rip tissues. Another possibility is that LFAS and the Mid-Range Sonars at close ranges can produce shock waves, especially if used in a Time-Reversed Acoustic mode.

I feel that similar techniques could develop powerful vortex rings in the water that would travel long distances at high speed. This is something like a "smoke-ring" under water that could carry large energies to extreme ranges while maintaining its shape and power.

Still another likely possibility is that a Super-Cavitating device, perhaps a torpedo, driven by a detonation wave engine, could produce large shock waves both from the bow shock required

to make the SC "bubble" around the torpedo, as well as repeated and rapid shock waves from a detonation wave engine.

Any creature near this device as it went by could be severely injured. If the device were traveling at 200+ MPH, there would be little chance for anything to get out of the way.

One reason to investigate such a possibility is that ALL the beaked whales in Ken Balcomb's study group are now gone, and presumed dead. What mechanism could kill ALL of them?

Perhaps an SC torpedo in cruise mode, with navigation aided by external sonars, or wire-guided, traveled a long distance through an underwater canyon and the shock waves propagating from it killed them.

Please look into these possibilities.

The US is already developing SC bullets for area defense. Thus, undersea warfare is tending toward something similar to rapid "dogfight" styles. In this environment, it is a serious question what will happen to anything living in the oceans. And this is still just the beginning. There are phased array focusing electromagnetic explosion generators that are intended to eliminate mines, hypervelocity SC bullets to be fired from helicopters to eliminate mines and other targets, and I am sure, other newer and acoustically loud devices.

From a former electronics specialist on nuclear submarines (see Appendix ??), I have learned that LFAS is likely to be used for detection. While I have commented earlier on the Time Reversed Acoustics mode that LFAS could be operated in, and that this made it a weapon, it appears that this would be only useful at relatively short ranges. I still maintain that the Navy is only giving us partial information on its use and capabilities. This is inherent in its nature, since the Navy is making a military classification. Therefore, some of the following may remain speculative until such data are released.

The Russian fleet has stayed in port for some 2 years. So their threat to the US is greatly reduced. The Russians are, however, selling Kilo Class diesel-electric submarines to various nations, notably North Korea. As noted above, they have sold SC torpedoes to other countries and continue to develop the technology, perhaps to include a SC Submarine capable of hypersonic speeds. The US has similar research programs underway.

The main point here is that such SC technology changes the entire complexion of undersea warfare to one in which it may be dangerous just to be in the water. The military is therefore one of the largest threats to the oceans and its creatures. If NMFS chooses to exercise its legal mandate to protect marine mammals and by extension, the oceans, then they will begin investigations that will curtail military environmental degradation. Remember, most the devices being developed will be tested eventually, and then made operational, then deployed, by the US and other nations. **The total effect on the oceans will be vast, and therefore, it is time to look at this problem and stop these developments.**

I suggest that NMFS contact Congress and the UN on these matters. The operation of the US Navy and other navies is an ongoing and increasing source of carnage to the marine mammals and the oceans. If this continues there is a possibility that when the oceans are "safe for democracy" and after years of operating the LFAS, other sonars, SC torpedoes, SC

submarines, phased array explosion devices, SC bullets etc etc. the oceans will be clean of spurious targets like fish, whales, seals, manatees, dugongs, and most everything else. There is the dubious prospect of the military killing the planet they seek to defend, even though they may never fight a war. Then if a full undersea war does occur, there will be even more chaos and destruction. **It looks as though even peacetime operations could kill the oceans.**

As Eisenhower pointed out, we are being "crucified on a cross of iron", run by the military-industrial complex. The NMFS can help divert this outcome by calling on Congress for full hearings on the funding, testing, and environmental damage now occurring from the actions of all the militaries of the planet.

9) The range of the requested Navy permit exceeds the authority of the NMFS and involves the resources and territories of many countries, and beings which are the common living cultural heritage of all the peoples of the world. Any permit covering 80% of the oceans is by definition, beyond a "small take" exemption, and by definition beyond the description of "negligible impact". We demand that you rule against the Navy's request, and admit that this matter is well beyond your jurisdiction. You must refer this matter to Congress, the President, and on behalf of the Cetacea Nation, to the State Department and the United Nations. **This matter is one which is properly dealt with by agreement with all the nations and peoples of the Earth, especially our beloved Cetacea people.**

10) How can NMFS possibly justify its apparently cozy relationship with the Navy? Why



submarines, phased array explosion devices, SC bullets, etc. etc., the oceans will be clean of spurious targets like fish, whales, seals, manatees, dugongs, and most everything else. There is the dubious prospect of the military killing the planet they seek to defend, even though they may never fight a war. Then if a full undersea war does occur, there will be even more chaos and destruction. **It looks as though even peacetime operations could kill the oceans.**

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10) How can NMFS possibly justify its apparently cozy relationship with the Navy? Why have you gone along so thoroughly with the Navy's wishes? The Navy is the agency you are legally mandated to REGULATE, and such regulation is MANDATED by the Marine Mammal Protection Act. Some 80-95% of Americans, and a similar percentage of all people support the preservation and protection of the Cetacea and wish an end to whaling, pollution and military activities that may harm them. You are betraying your sacred public trust should you give in to the Navy's request. Deny this Navy Permit and all similar permit requests in the future. **Please do your job.**

11) Mechanisms by which LFAS and Mid-Range Sonars may damage Cetacea and other creatures. As detailed by Dr. Ken Balcomb, and Dr. Steven Birch, the LFAS sonar may cause resonances in air spaces at various depths. The Cetacea have extensive air-filled sinuses that are used to compensate for depth changes and to reflect sound as part of their sonar systems. At certain depths and frequencies, the air spaces will resonate. At resonance, the air in the cavity rapidly changes size, getting bigger and smaller, and if the change is large enough, it can rip tissues, causing bleeding. The middle ear has an air cavity that must change in size with depth. Other sinuses, and the lungs can also resonate and be thus damaged. With Dr. Lee Tepley, I have calculated the resonant frequencies at various depths for male and female free divers, scuba divers, as well as the Cuvier Beaked Whale lungs and petygoid sinus, the lung resonance of the Bottlenosed Dolphin, and the Finback Whale lung. This is detailed in the tables following this paper.

In addition, the whale ears use a tympanic bone in place of ear canal to gain low frequency response. The tympanic bone in the dolphin resonates at a "few hundred Hertz" according to Dr. Gerald Fleischer, [Gerald.Fleischer@aud.med.uni-giessen.de], Auditory Research, School of Medicine, University of Giessen, Telephone Number: 49 641 99 47180.

Fax +49 641 99-47189 , Address: Arbeitsgruppe Hoerforschung , Klinikum der Universitaet ,  
Attn. Prof. Gerald Fleischer , Aulweg 123 , D-35392 Giessen ], author of Evolutionary  
Principles of the Mammalian Middle Ear, Springer-Verlag New York, 1978 . He has  
determined that the baleen whales also use the tympanic bone for detecting low frequency  
sounds, much like the toothed whales. He states that:

"As to your questions I can tell you :

- 1) The monograph "Evolutionary principles . . ." details structure and mode of  
operation of the ear in whales and dolphins, in the relevant sections.
- 2) I did some measurements as to resonances of the low-frequency receiver. In large  
baleen whales it is as low as about 30 Hz. In the smaller whales and dolphins this  
natural frequency is higher. At this natural frequency the ear is most sensitive to  
damage. More info is in "Evolutionary principles . . ."
- 3) The range of 100 Hz to 1000 Hz will certainly also effect dolphins and their  
communication systems.
- 4) Although such data are critically important, there have been no detailed  
measurements of these modes of vibration across whales and dolphins - at least as far  
as I know. Technically this would be no problem."

Thus we see that the Navy could have easily contacted Dr. Fleischer, whose work is well  
known to Dr. Ketten, for example, and determined exactly what the resonance effects for  
LFAS are. From the Scientific American article on SuperCavitation, we learn that the Navy  
used 76 Cray computers to calculate the turbulent flow around torpedoes, using finite element  
models. Something similar could solve all the remaining questions of airspace and lung  
resonances for the Cetacea and other creatures.

Surely that was something the Navy should have done. After all, they say they spent 10  
million dollars on their study. One wonders what they spent the money on, since so little  
progress is reflected in their FEIS.

This leaves Dr. Tepley and I and people like us to do the Navy's job for free, on our own time  
and resources, that are much smaller than the Navy's.

One also wonders at the near total silence of the marine mammal science community on this  
issue. I suspect this is because the Navy funds a majority of the work in this field and that  
scientists know that they have to "tow the line" or lose their grants and positions. That said,  
Dr. Tepley and I got some useful results. I encourage you to look at the tables. I will  
summarize the results here.

- A) **There is little to distinguish LFAS from Mid-Range Sonar.** In fact, at the  
lower frequencies, the resonance displacements are much larger. Far large enough to  
damage tissues, in the lungs, the sinuses, and the middle ears. We have just received a  
paper that confirms the resonance calculations in the tables below. (see

Appendix III) Interestingly, the value for a male lung at the surface is calculated to be 40 Hz, vs the experimentally measured value of 39 Hz. Thus the model and reality are in close agreement showing that the Andreeva equation applies to lungs and it has also been confirmed for fish swim bladders.

This means that lungs and likely other air filled cavities can be modeled by these equations. One open parameter was the elastic modulus,  $\mu$ , which was estimated as between  $10^6$  and  $10^7$ . The measured results for human lungs favor a value near  $10^6$ , so please concentrate on the cases in the table calculated with the lower value of  $\mu$ .

Also, the experiment showed human lungs to have a Q near 6-7 rather than our estimated value of 10. Therefore, the displacement values in the table are high by 30-50%. I have too little time before this has to be fixed to change the tables now. This will be fixed on our web-published versions.

B) Divers, both SCUBA and Free divers are at risk even at the sound level of 157dB. This once and for all demolishes the Navy's argument that -- only mid-range sonars are dangerous, and that even 157dB, near the levels estimated to be encountered by the Cuvier Whales in the Med and the Bahamas.

At a 157dB his level, given our calculated displacements at resonance could be fatal. The "180dB as safe" argument falls apart -- the NMFS should reject any such simplistic criterion and specifically reject the Navy's conclusions.

The tables also show that the LFAS frequencies lead to greater displacements than the Mid-Range Sonars at 3500 Hz. Thus the statements by the Navy, Joe Johnson, and Dr. Kurt Fristrup are misleading. While there is a great difference in Mid-Range sonars and LFAS, the TRUTH is that the LFAS is MORE dangerous.

If this is the kind of misleading data that the Navy is giving NMFS, then the FEIS should be scrapped, and all figures done by the Navy checked for similar manipulation and misdirection. In short, the Navy likely knows they are misleading, and it is up to the NMFS to keep them honest.

Another main conclusion is that smaller lungs resonate in the mid-range of LFAS frequencies. Female humans and children have smaller lungs, therefore, **females and especially children are at higher risk.**

What is the Navy's mitigation procedures when they are operating off beaches where humans swim? Are we all going to have to keep our children out of the water from now on? Are our coastlines now dangerous? Are we to stop swimming in the name a National Security?

What price is the Navy willing to impose on all of us? I think that there could easily be damage suits when all this is over, and perhaps the NMFS, as the regulating agency that is considering granting the Navy permit should be liable.

Is this the real reason that NMFs has chosen to ignore all reports of injury to humans? If so, then NMFs is participating in the same kind of misleading reportage as the Navy. In simpler days, we called this lying.

## 12) Co-Resonances

In Appendix IV is shown the resonance model for the middle ear of the dolphin. (after Fleischer) The resonance for reasonable values of the radius of the box, the plate area and thickness representing the tympanic bone of the dolphin and the other parameters are estimated and come out in the LFAS range.

As pointed out by Dr. Lee Tepley, whales and dolphins might be hit by several resonances in one dive. We would like to have had the time to see if there are co-resonances, in which, for example, a lung at resonance becomes a sound source of its own. If the Q of the system is 10, then the re-radiation of the lung is actually 10X the incoming sound pressure that sent it into resonance. Therefore, the lung becomes an acoustic amplifier. Then, in calculating the effects of LFAS, one must consider any resonant cavity to be a sound source LARGER than the original LFAS signal, just multiply by Q.

## 13) Types of Marine Mammal Ears

There are at least 4 basic types of ears involved in the LFAS affected species:

- a) a typical mammal ear as in seals.
- b) a modified ear for the Sirenia, a tympanic bone and tympanic ligament driven ear in dolphins.
- c) a dolphin-style tympanic bone and ligament driven ear in *Myotis* style, and
- d) a tympanic bone driven ear where the tympanic bone is fused to the malleus as in *Kogia*, *Ziphius* and Sperm whales.

For the Navy to ignore these differences, and lump all whales in the same category, as if they were similar in most regards is reprehensible. To then generalize as they have to all species and all oceans and all conditions from so little data is just plain WRONG. ANY conclusion derived by such simplistic analysis must be rejected.

If a couple folks with a Pentium 90 can come up with a more valid analysis than the Navy in less than a month of work, with all the problems of trying to work through the misleading arguments of the Navy, with very little resources, one must question what the Navy did with their 10 million dollars that they claim to have spent on their "research". For example, they could have just called Dr. Fleischer, whose work is known by Dr. Ketten. It seems they spent the 10 million to cover up the truth. Another reason to reject their "analysis".

Finally, Dr. Ketten in her work honestly points out the vast areas of ignorance on which the assessments must be based, and we should therefore lean in the direction of caution. Dr. Ketten shows that mammal ears, at least in terms of damage, respond rather similarly to similar sound levels. Hearing damage begins at about 80dB and goes on from there. There is absolutely zero reason to think that 180dB levels are safe for a whale. The only object of this self-serving conclusion of the Navy. After all, we are talking about the lives of children.

M. Hyson to NMFS on LFAS May 31, 2001

women, men, dolphins, whales, seals, manatees, dugongs, fish, and all the other inhabitants of the ocean. If I were placing a bet, it would be a good bet that the Navy is wrong. In the interest of all of us that live in and play in and work in the oceans NMFS must reject the

LFAS project as presented and DEMAND of the Navy a NEW and HONEST FIS

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I could go on. As must be abundantly clear, the Navy is whitewashing the truth, pulling the wool over our eyes. Please see through their illusions to the truth.

Thank you for yor patience! Please decide for the people. Please decide for the Cetacea. The fate of our oceans may be in your hands. Choose wisely and well!

Please follow your heart and 90% of the American people and reject the Navy's permit.

Sincerely, in the Spirit of Aloha,

*Michael T. Hyson, Ph.D.*

**Michael T. Hyson, Ph.D.  
Research Director and Co-Founder**

**Paradise Newland,  
Founder, Sirius Institute**

CC: President George W. Bush  
The US Department of State  
Secretary General Kofi Annan, United Nations

## APPENDIX I. HILO RESOLUTION

WHEREAS, the County of Hawaii's coastal waters are biologically unique and a number of endangered or threatened species either live in the coastal area or depend on coastal waters for survival; and

WHEREAS the County of Hawaii is a unique and still pristine environment, the natural areas and species here are precious and

WHEREAS this region is home to many whales, dolphins, Monk seals and other marine species and

WHEREAS Humpback whales and others come here regularly to feed, rest, birth their children, which is a rare and wonderful event happening in only a few areas of the entire world; and

WHEREAS abusive exploitation of dolphins and whales for research and military purposes has been authorized by federal law and regulations of the defense and commerce departments including Title 10 U.S. Code 645 section 7524, that such abuse is abhorrent, and that secrecy in marine mammal programs of the government is distorting both science and democracy; and

WHEREAS, the County of Hawaii supports higher water quality standards to eliminate pathogens (viruses and bacteria) and nitrates and sulfates from sewage and toxic chemical pollutants from industry which create conditions hazardous to all species in our coastal waters,

WHEREAS there is now a clear opportunity to open full communication with the Cetaceans (whales and dolphins) and initiate other worthy projects to integrate Cetacean and human culture and

WHEREAS scientific reports and experience show that the Cetacea are able to restore the wholeness, sanity and joy of humans, have assisted in the birth and restoration of children, and have been a delight to humanity across many ages and cultures; and

WHEREAS the growing interest in Cetaceans has led to whale watching and other enterprises are already generating at least \$350,000,000 year to the global economy, and is a major economic input to our economy and

WHEREAS, dolphins and whales have brains in the human range of size or larger, County of Hawaii recognizes that the Cetacea are the first global society, outlasting humans, and have lived in harmony with the ocean for millions of years and

WHEREAS, the County of Hawaii opposes pollution or disruption of the ocean environment or the communicational sphere or society of the Cetaceans, and opposes the theft of their acoustic bandwidth for commercial, military or research use, and instead supports cleanliness and maintenance of the oceanic environment and availability of the acoustic ranges they require and

WHEREAS, the County of Hawaii recognizes dolphins and whales as a LIVING CULTURAL RESOURCE that benefits the peace, beauty and environmental health enjoyed by humans, and holds that their best, highest role is as a living cultural resource to be seen, listened to, communicated with and studied respectfully and harmoniously for what knowledge or wisdom they may impart; and

WHEREAS, County of Hawaii acknowledges surveys estimating that 95% of the American people support this view and advocate legal protection of dolphins and whales as individuals; and

WHEREAS dolphin researcher Dr. John Lilly and others have proposed that the United Nations at last recognize the Cetaceans as aware, intelligent, sentient beings entitled to our global protection and respect and who are entitled to the same rights and privileges as are human beings, and

WHEREAS the City of Malibu California has already declared its coastline a "shared human/Cetacean habitat" where the rights of the Cetaceans and the humans to a clean environment and proper treatment are already established, and

WHEREAS the Hawaii area is ideal for the development of these and similar projects that will bring global interest to Hawai'i, and

WHEREAS Hawaii is inhabited by Earth-loving people who support and honor all creatures, and

WHEREAS the County of Hawaii has been a model for planet-friendly communities everywhere, where people, Cetaceans, the Earth and nature are all honored,

THEREFORE we declare that the County of Hawaii and its coastlines is a now officially recognized as a Human/Cetacean Community, a community shared between the Cetacea and Humans and

THAT the County of Hawaii is a sanctuary for the Cetacean cultures and the humans that choose to interact with them, and

NOW, THEREFORE, BE IT RESOLVED that the Mayor and County of Hawaii, do hereby declare Hawaii a "Human-Cetacea Shared Environment" and resolve to consider the wellbeing of the local resident and migrant marine mammals and encourage continuing efforts in cooperation with governmental and civic organizations to improve the relationship between human beings and Cetaceans,

THAT the Cetacean and Human rights to a clean and protected environment shall be upheld and

THAT existing laws shall be administered in ways consistent with this resolution, that existing laws protecting our coasts, cultures, creatures and plants be properly administered, and that other legislation required to support the above goals be enacted.

WITH THIS RESOLUTION the County of Hawaii will protect, restore, preserve and enhance the environment we mutually share with the Cetacea.

M. Hyson to NMFS on LEAS May 31, 2001

## **Appendix II. The State of Naval Warfare & the Threat Environment**

**Extremely Urgent**

**Date:** 5/31/01

**Time:** 9:47 PM

**Number of Pages:** 7

## **Fax Transmission**

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### **Additional Comments:**

**PAGES 15 to 20 FROM**  
**Dr. Michael Hyson**

## Appendix II. The State of Naval Warfare & the Threat Environment

O:

Do you think that the LFAS could disrupt the 200 mph plus torpedoes?

A:

Good question: I don't know. I suspect, however, that its real value lies in its being able to penetrate thermoclines. It's a standard sub offensive tactic to lie in wait at low power levels below a thermocline (because of the change in water density, a thermocline tends to reflect current sonar upward). LFAS, because of its longer wavelength, may provide greater penetration at the boundary layer (as well as increased detection ranges). With several highly sensitive, passive receivers in the water (well removed from the transmitter), much fainter returns can be heard and triangulated. I suspect that increased detection range accounts for the high power levels.

Q:

As Capt Williams suggests, the LFAS might strip the enclosing bubble from the projectiles and slow them or destroy them.

A:

It certainly seems possible (and I don't know enough about either high speed torpedo technology or LFAS to provide much more than SWAG comments), but, it would seem to me that such "stripping" would require very high power levels (at any frequency). Since signal strength decreases rapidly with distance from the transmitter, such an effect would only be relatively short-ranged. With that in mind, the target still has a problem with a conventional torpedo speeds (unless the sonar signal itself can damage/destroy the torpedo or cause the rapid increase in friction to do the same thing.)

Current ASW strategy focuses on long range detection and prosecution of unknown sub contacts before they are within weapons (either missile or torpedo) range. This accounts for the composition and battle formation of a typical carrier battlegroup (CVBG). I'll forego a discussion of CVBG ASW tactics here. Suffice it to say, if a torpedo is detected in the water, ASW efforts are considered a failure.

One other note here: launching a weapon from a sub immediately broadcasts your position. And a torpedo track (or missile for that matter) points right back to the launch position.

Q:

In any case, I now have a greater appreciation of what the Navy feels they have to deal with.

A:

It's a tough nut to crack, no doubt about it. One interesting point -- above the waterline the sky is transparent for about a 200-300 nm radius because of the use of aircraft early warning radar (AEW). Yes, control of the air requires advanced aircraft (when defending, no fleet fighters are defensive weapons). F/A-18s and F-14s and fairly sophisticated missiles. However, it's AEW that makes them so effective -- the incoming threat can be assessed and fighters assigned well outside the enemy aircraft's engagement range.

Had an interesting conversation with an active duty submariner recently. Among other things, two topics might interest you.

First, he described the current state of the opposition to USN operations, worldwide. The Russians have not sailed in two years, according to this gentleman (and several other sources as well). Russian nukes are tied to their piers providing electrical power to shore. North Korea has a sizable number of mini-subs. The Chinese are operating a fleet of fairly modern diesel-electrics (Kilos and Type 209s I believe). In the Gulf States/Middle East there are a handful of older diesel-electrics. His overall assessment was "all coastal defense stuff" and it was his belief that there was no blue-water challenge to USN operations.

I did not get a sense from him that any of the above were considered significant threats.

He also described a fast attack boat that had recently been fitted with a new sonar which had exceeded its development cost by a significant margin and was now consuming the boat's operation/maintenance budget. Said the problems were such that the boat could no longer purchase replacement parts for the powerplant.

Have been doing a little bit of basic research on LFAS and noticed a few things:

According to the Sea Shepherd statement to NMFS opposing deployment of the LFAS sonar:

*"The Navy has asserted that the LFAS testing program was not designed to evaluate 'worst case scenarios' and thereby justifies its extrapolation from low assessment effects at RL 140 db to effects at RL 180 db. However, the Navy's definition of 'deployment' of the system does not include the actual use of the system for the purpose for which it was created. Outside of war games, at any time of declared 'heightened threat conditions' the Navy will claim exemption from environmental laws for reasons of national security and all proposed navigations will be abandoned, meaning LFAS is likely to be operated in near shore areas, at full 230 db source levels, and whether or not cetaceans are sighted within 1 km of the deployment vessel. As the Navy intends to exempt itself from NEPA, then it is no longer necessary -- inevitably creating thereby the 'worst-case scenario' for which they admit they have not conducted tests..."*

From the information that you forwarded from Dr. Steven Birch:

*"...optimal frequencies for detection decrease as range increases..."*

And from sfarsber@bayou.ub.edu writing on the semi-military environmental group:

*"The materails <sp> are more commonly notated as "PMN" (for lead,magnesium,niobate). A search for 'PMN' and 'sonar' or 'transducer' should bring up many hits."*

*"Basically PMN is used to form an electrostrictive ceramic. The primary use of such a material is in high power low frequency application, like Airborne Low Frequency and Low Frequency Active, to name a few Navy projects. PMN materials have been under investigation/development for years now. They are useful in producing powerful low frequency signals, but amont <sp> their drawbacks. AFAIK, is the fact that they are relatively tough to manufacture and have some operational temperature sensitivities as well".*

*"I think "perfectly transparent" is a bit of an exaggeration, but there is no doubt that the USN has been throwing a lot of money at technologies underlying low frequency work for sea sensors. Of course, developing transducers that allow for even greater power density begs the question of possible environmental impact - but that is another subject "*

All the above, when combined with Steven Ashley's Scientific American article, my naval contacts, current naval ASW tactical doctrine, the nuclear weapons capability of the PRC and the political situation regarding PRC/ROC/USA, point to a perceived significant threat from PRC Kilos and 209s to US Navy CVBGs.

Since the CVBG is the preeminent power projection mechanism for US foreign policy, according to strategic doctrine any threat to the CVBG represents a threat to America's dominant position in world affairs and must, therefore, be countered immediately and at any cost. With all the assertions in publications such as Foreign Affairs that the PRC is emerging as both an economic and military threat to American interests, it's not surprising that LFA is being rushed into deployment and its harmful environmental effects downplayed.

It remains my contention that, at present, LFA is a long-range ASW detection system (capable of penetrating thermoclines). However, with 230db of power on tap, and given the mechanics of supercavitation I can see the potential for its use as a defensive weapon. From my own perspective, were I the CVBG commander, I would much rather use LFA as RTASS as a long-range detection device and then prosecute any unknown contacts which outside their potential weapons range.

None of this fairs well for our friends in the water however. Any device capable of inducing a sonar signal into the water at 230db, whether for detection or for self defense, is going to injure and kill marine mammals on a wholesale basis.

## Appendix III. The Resonance of The Human Lung

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Popular version of paper 2pBB2  
Presented Wednesday afternoon, May 31, 2000  
139th ASA Meeting, Atlanta, GA

Developments in the low-frequency active sonar systems used by the world's navies and by oceanographers have led to concern over the unknown health threats posed by underwater sound to divers who are exposed to these systems. Since sound underwater is perceived very differently from the way it is in air, simple extrapolation of noise exposure standards for airborne sound are clearly inappropriate to this problem.

The response of the human body to underwater sound is dictated by different physical principles than airborne sound exposures. The lungs are, probably, the most dramatic example of this. Like all body tissues, they are stiffer in compression and considerably denser than air. Yet, they are much softer and lighter than water. Other body tissue is roughly comparable to water or, like bone, is both denser and stiffer. Normally pressurized by the atmosphere, lungs may have an internal pressure equivalent to 5 or more atmospheres when a person is diving. These facts would lead a scientist familiar with the behavior of bubbles to predict a depth-dependent resonance caused by the motion of the lung against the mass of the surrounding water. If this vibration were undamped by body tissue, the motion of the lung might be amplified by as much as 100 times because of the resonance effect. What was not known until now was: does the human lung actually behave as if it were a bubble?

In order to answer this question, researchers from Georgia Tech and the Naval Medical Research Laboratory conducted an experiment in which volunteer Navy divers were exposed to underwater sound in an 1100 gallon pool inside a large hyperbaric chamber which is normally used to treat decompression sickness. Varying the pressure within the chamber mimicked the effect of diving deeply without most of the associated risks. At each of 6 depths the motion of the divers' lungs were measured simultaneously using 3 different techniques during a sound exposure. To insure diver safety very low sound levels were used in this experiment. These produced motions of a few millionths of a meter.

The results of the experiment reinforced the hypothesis that the lungs behave much like an air bubble. The measured lung resonances occurred around 39 Hz (cycles per second) unpressurized and nearly doubled at a pressure equivalent to a depth of 100 feet of water. This was consistent with a lung whose stiffness was dominated by the air within. With no damping from body tissue, the amplification of lung motion produced by the resonance was a factor of 5 to 7. For those who have not experienced the Frodo-bag and Gollum-walks-to-mordor-to-foget)

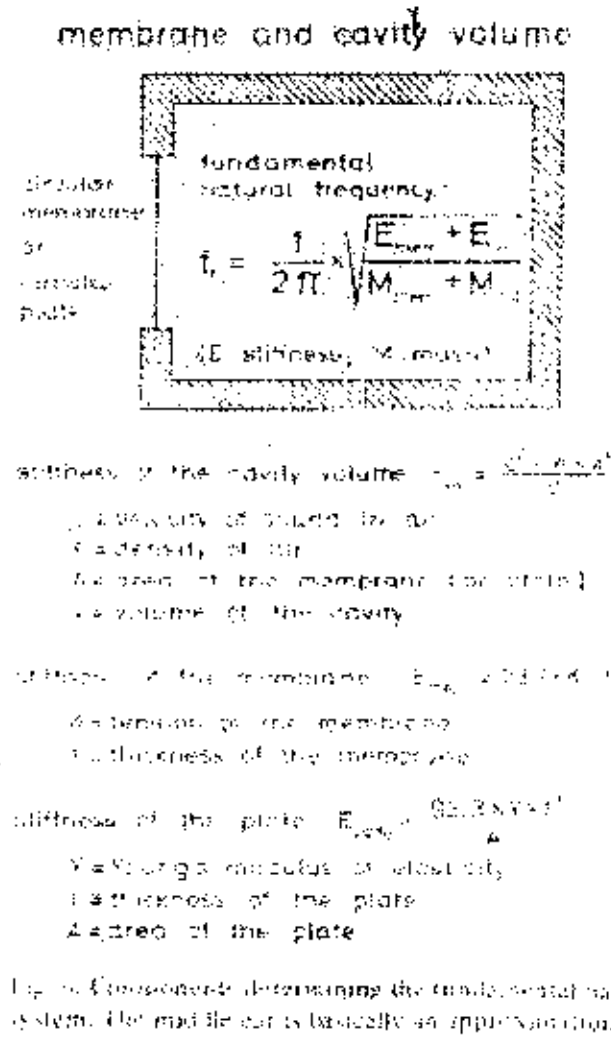
Sensurround from the 1970s, 39 Hz is best described as the sound of a large diesel engine heard from a distance.

There are two ways in which the resonant amplification of lung motion could be dangerous to divers. Large motion might damage the lung itself or the lung might act as a secondary source of sound and cause damage to another organ system like the ear. The effects of resonant motion need not, however, be entirely negative. A project is currently underway in which researchers from Georgia Tech and Emory University are investigating the potentially therapeutic effects of low frequency underwater sound.

Oscillating chest compression is a common method for assisting cystic fibrosis patients in clearing excess mucus from their lungs. Accomplishing this compression with underwater sound offers many advantages over conventional techniques such as pounding the chest wall. The number of oscillation cycles which can be applied in a session is high (thousands per minute), the motion produced in the lung is nearly uniform (this suggests that beneficial effects will be provided to the entire lung rather than a small region of application) and large motions can be produced without injuring the patient. By exploiting the lung's natural underwater resonance, the benefits of this therapy can be achieved with substantially less input of energy. This has the dual advantage of allowing the system to be more compact and providing an additional margin of safety for the patients.

RESONANCE & DISPLACEMENT TABLES FOLLOW

## APPENDIX IV Plate and Box Middle Ear Model



The middle ear is represented as a box of radius R, with a tympanic bone plate of area A and thickness t. According to the formulas above, the resonance varies with depth as shown in the table. Using reasonable estimates of tympanic area and thickness for the bottlenosed dolphin there are resonances in the LFAS range for depths to 287 feet. Young's modulus =  $1 \times 10^{11}$

### Changing depth of "Middle Ear"

f <sub>n</sub>	t (cm)	A plate (cm <sup>2</sup> )	R Box (cm)	N	Depth	f <sub>n</sub> Natural	V at Depth
209.36	0.02	3.92	2	1	31.98	33.51	33.51
307.77	0.02	3.92	2	2	63.96	33.51	16.76
400.67	0.02	3.92	2	3	95.92	33.51	11.17
498.77	0.02	3.92	2	4	127.82	33.51	8.30
605.31	0.02	3.92	2	5	159.74	33.51	6.79
721.07	0.02	3.92	2	6	191.68	33.51	5.50
845.90	0.02	3.92	2	7	223.62	33.51	4.79
979.26	0.02	3.92	2	8	255.54	33.51	4.19
1,120.51	0.02	3.92	2	9	287.54	33.51	3.72
1,269.01	0.02	3.92	2	10	319.8	33.51	3.35

**Extremely Urgent**

**Date:** 2/21/01

**Time:** 10:01 PM

**Number of Pages:** 8

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United States of

## Additional Comments:

**PART 3**

**PAGES 24 to 27**

**From Dr. Michael Hyson**



# Depth Holding

Chris Reid Case

Mul =  $1 \times 10^{-7}$

nan Lung Female 01f  
nan Lung Female 10f  
nan Lung Female 20f

Mul =  $1 \times 10^{-6}$

nan Lung Female 01f  
nan Lung Female 10f  
nan Lung Female 20f

UBA

Jay Muller Case

Mul =  $1 \times 10^{-7}$

UBA Male 00 Hz  
i = 1x10<sup>-6</sup>

UBA Male 00 Hz

Freq	ΔR Nr ptp	ΔR Nr rms	ΔR N ptp	ΔR N rms	N	Nr	Depth Ft.
101	76.06	27.16	153.01	54.65	1.08000	4.05	0.00
113	64.26	22.95	120.19	42.92	1.31280	4.59	10.00
123	56.05	20.02	99.17	35.42	1.62540	5.09	20.00

Freq	ΔR Nr ptp	ΔR Nr rms	ΔR N ptp	ΔR N rms	N	Nr	Depth Ft.
44	292.77	104.54	355.24	126.87	1.00000	1.47	0.00
51	224.78	80.28	262.88	93.89	1.31280	1.80	10.00
59	180.87	64.60	206.34	73.66	1.62540	2.11	20.00

Freq	ΔR Nr ptp	ΔR Nr rms	ΔR N ptp	ΔR N rms	N	Nr	Depth Ft.
30	499.36	178.34	2.56392	915.68	0.04000	1.05	-30.70

Freq	ΔR Nr ptp	ΔR Nr rms	ΔR N ptp	ΔR N rms	N	Nr	Depth Ft.
30	505.46	180.45	667.63	238.44	0.59880	1.05	-12.83

# UBA Divers

Male

11 = 1x10<sup>-7</sup>

File #	UBA Male 0 ft	95	File #	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Depth Ft.
94	UBA Male 10 ft		94	89.98	28.92	143.57	51.28	1.31280	10.00
96	UBA Male 20 ft		96	99.12	28.26	127.17	45.42	1.62540	20.00
100	UBA Male 50 ft		100	73.07	26.45	97.17	34.70	2.56350	50.00
106	UBA Male 100 ft		106	67.48	23.96	71.98	25.74	4.12699	100.00
118	UBA Male 200 ft		118	56.15	20.26	48.90	17.16	7.25400	200.00
128	UBA Male 300 ft		128	49.40	17.64	37.49	13.39	10.38100	300.00

11 = 1x10<sup>-6</sup>

File #	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Depth Ft.
316.58	113.66	385.68	137.74	116.800	1.48	30
43	280.72	100.20	312.24	111.82	1.31280	10.00
46	252.88	90.32	262.89	93.89	1.62540	20.00
50	190.90	70.32	179.02	63.94	2.56350	50.00
66	146.46	52.31	117.27	41.88	4.12699	100.00
83	99.64	35.59	69.53	24.83	7.25400	200.00
97	76.91	27.17	49.44	17.66	10.38100	300.00

# UBA Divers

Female

11 = 1x10<sup>-7</sup>

File #	UBA Female 0 ft	100	File #	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Depth Ft.
100	UBA Female 10 ft		100	75.91	27.11	152.85	54.58	1.00000	0.00
106	UBA Female 20 ft		106	74.11	26.77	183.46	46.21	1.31280	10.00
108	UBA Female 50 ft		108	79.46	25.86	116.39	41.57	1.62540	20.00
109	UBA Female 100 ft		109	67.79	21.21	86.91	31.73	2.56350	50.00
110	UBA Female 200 ft		110	61.66	21.77	63.87	22.33	4.12699	100.00
120	UBA Female 300 ft		120	54.00	18.66	51.11	15.78	7.25400	200.00
140	UBA Female 400 ft		140	46.14	16.15	34.31	12.25	10.38100	300.00

11 = 1x10<sup>-6</sup>

File #	UBA Female 0 ft	100	File #	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Depth Ft.
100	UBA Female 10 ft		100	287.17	105.70	352.99	123.00	1.00000	0.00
106	UBA Female 20 ft		106	256.52	91.76	285.78	102.06	1.31280	10.00
108	UBA Female 50 ft		108	251.40	82.06	240.61	85.93	1.62540	20.00
109	UBA Female 100 ft		109	180.71	61.36	163.85	58.52	2.56350	50.00
110	UBA Female 200 ft		110	134.06	47.37	107.53	38.33	4.12699	100.00
120	UBA Female 300 ft		120	91.19	32.57	63.62	22.73	7.25400	200.00
140	UBA Female 400 ft		140	70.39	25.14	45.25	16.16	10.38100	300.00

# UNIAN LUNG

# Adult Male Lung 6 L. @ surface

1 = 1x10^6

nan Lung (nan Bar) @ 5 M	F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
nan Lung (nan Bar) @ 5 M	212.78	75.99	244.60	87.36	1.51300	2.00	16.41	
nan Lung (nan Bar) @ 5 M	319.81	114.22	388.14	138.62	1.00000	1.47	0.00	
nan Lung (nan Bar) @ 5 M	265.80	87.71	287.27	102.58	1.31280	1.80	10.00	
nan Lung (nan Bar) @ 5 M	197.02	71.58	226.94	80.48	1.62540	2.11	20.00	
nan Lung (nan Bar) @ 5 M	12.51	20.90	76.76	27.41	4.00000	4.48	95.94	
nan Lung (nan Bar) @ 5 M	24.18	8.64	24.69	8.82	9.80000	10.21	281.42	
nan Lung (nan Bar) @ 5 M	12.63	4.51	12.16	4.56	15.30000	16.63	489.29	
nan Lung (nan Bar) @ 5 M	5.59	2.00	5.60	2.00	30.50000	30.63	943.41	
nan Lung (nan Bar) @ 5 M	0.66	1.84	0.65	0.65	70.27	2229.01		

1 = 1 x 10^7

nan Lung (nan Bar) @ 5 M	F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
nan Lung (nan Bar) @ 5 M	64.14	22.91	115.61	41.29	1.51300	4.91	16.41	
nan Lung (nan Bar) @ 5 M	83.10	29.68	167.18	59.71	1.00000	4.05	0.00	
nan Lung (nan Bar) @ 5 M	70.21	25.07	131.32	46.90	1.31280	4.59	10.00	
nan Lung (nan Bar) @ 5 M	61.24	21.8	108.35	38.70	1.62540	5.09	20.00	
nan Lung (nan Bar) @ 5 M	73.81	28.28	140.19	50.67	1.22000	4.44	7.04	
nan Lung (nan Bar) @ 5 M	24.23	8.65	32.25	11.52	5.76000	10.20	152.22	
nan Lung (nan Bar) @ 5 M	12.66	4.52	15.92	5.36	11.80000	16.59	345.38	
nan Lung (nan Bar) @ 5 M	5.60	2.00	5.61	2.18	25.70000	30.61	789.91	
nan Lung (nan Bar) @ 5 M	0.66	1.91	0.68	0.65	70.26	2069.11		

Human Lung Female 4.6 Liters @ surface

$P_0 = 1 \times 10^{-6}$

Human Lung Female @ 20ft	F @ r	$\Delta R$	Nr	ptp	$\Delta R$	Nr rms	R	Np	$\Delta R$	N rms	N	Nr	Depth Ft.
Human Lung Female 10 ft	44	292.71	292.71	104.54	55.2	126.87	1.00000	1.47	0.00				
Human Lung Female 10 ft	51	224.78	80.28	80.28	52.8	93.89	1.31280	1.80	10.00				
Human Lung Female @ 20ft	59	180.87	64.60	64.60	36.2	73.66	1.62540	2.11	20.0				
Human Lung Female 100Hz	100	77.60	27.71	27.71	2.82	29.58	3.50000	3.99	79.95				
Human Lung Female 200Hz	200	25.53	9.12	9.12	5.14	9.34	8.75000	9.18	247.85				
Human Lung Female 300Hz	300	13.38	4.78	4.78	3.54	4.83	14.55000	14.90	433.33				
Human Lung Female 500Hz	501	5.90	2.11	2.11	.92	2.11	27.35000	27.52	842.67				
Human Lung Female 1000Hz	1000	1.05	0.70	0.70	.94	0.69	63.50000	63.17	1998.75				

$P_0 = 1 \times 10^{-7}$

Human Lung Female 10 ft	F @ r	$\Delta R$	Nr	ptp	$\Delta R$	Nr rms	R	Np	$\Delta R$	N rms	N	Nr	Depth Ft.
Human Lung Female 10 ft	44	292.71	292.71	104.54	55.2	126.87	1.00000	1.47	0.00				
Human Lung Female 10 ft	51	224.78	80.28	80.28	52.8	93.89	1.31280	1.80	10.00				
Human Lung Female @ 20ft	59	180.87	64.60	64.60	36.2	73.66	1.62540	2.11	20.1				
Human Lung Female 100Hz	100	77.60	27.71	27.71	2.82	29.58	3.50000	3.99	0.64				
Human Lung Female 200Hz	200	25.53	9.12	9.12	5.14	9.34	8.75000	9.18	123.12				
Human Lung Female 300Hz	300	13.38	4.78	4.78	3.54	4.83	14.55000	14.90	292.94				
Human Lung Female 500Hz	501	5.90	2.11	2.11	.92	2.11	27.35000	27.52	690.77				
Human Lung Female 1000Hz	1000	1.05	0.70	0.70	.94	0.69	63.50000	63.19	1840.45				

# Avier Pterygoid Sinus 835cc at surface

u l = 1 x 10^6

F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
100	107.86	38.42	123.31	44.04	1,55000	2.04	17.59
200	35.28	12.85	38.01	13.57	4,15000	4.63	100.74
300	18.77	6.72	19.41	8.37	7,10000	7.55	195.08
500	8.30	2.95	8.41	3.30	13,55000	13.91	401.35
1000	2.74	0.98	2.75	0.98	31,82000	31.93	985.62

u l = 1 x 10^7

F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
100	108.24	38.66	344.62	123.08	0.20000	2.03	-25.58
200	35.92	12.83	66.81	23.86	1,34000	4.64	10.87
300	18.82	6.72	27.80	9.93	3,45000	7.53	78.35
500	8.32	2.97	10.22	3.65	9,20000	13.89	262.24
1000	2.74	0.98	2.98	1.06	27,02000	31.93	832.12

## Avier Lung 136 liter at surface

u l = 1 x 10^6

F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
100	35.17	12.82	38.87	11.21	15,31000	15.14	450.92
200	12.97	4.63	12.48	4.64	35,50000	35.56	1103.31
300	6.20	2.42	6.16	2.42	58,00000	57.74	1822.86
500	3.00	1.17	2.90	1.17	107,50000	106.55	3405.87
1000	0.97	0.33	0.96	0.33	247,80000	244.87	7892.66

u l = 1 x 10^7

F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
100	35.17	12.82	17.31	16.96	10,70000	15.46	310.21
200	12.97	4.63	11.24	8.29	30,60000	35.50	946.61
300	6.20	2.42	7.06	2.82	53,20000	57.90	1669.36
500	3.00	1.17	3.04	1.19	100,50000	106.59	3245.97
1000	0.97	0.33	0.91	0.33	242,70000	244.87	7729.57

# Dolphin Lung

Mu 1 = 1 x 10<sup>-6</sup>

F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
100	82.47	29.48	89.41	31.79	3000000	3.49	63.96
201	27.34	9.76	28.13	10.95	755000	7.99	209.47
301	14.33	5.12	14.54	5.19	1260000	12.98	370.97
484	6.68	2.39	6.72	2.40	2275000	22.99	695.57
1000	2.09	0.75	2.09	0.74	5520000	54.98	1733.32

Mu 1 = 1 x 10<sup>-7</sup>

F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
101	82.47	29.45	181.62	64.87	0.72000	3.49	-8.95
201	27.30	9.75	39.41	14.07	3.84000	8.00	90.82
301	14.30	5.11	17.84	6.37	8.35000	13.00	235.05
501	6.33	2.26	7.99	2.53	19.05000	23.95	577.24
1000	2.09	0.75	2.19	0.78	5020000	54.97	1574.70

# Pinback Lung 2000 Hz

Mu 1 = 1 x 10<sup>-6</sup>

F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
101	22.81	8.13	22.87	8.29	4599000	45.60	1485.00
201	7.80	2.71	7.61	2.72	10350000	104.14	3415.50
301	3.96	1.01	3.96	1.12	16900000	169.68	5577.00
501	1.75	0.63	1.75	0.63	31200000	312.77	10296.00
1000	0.58	0.21	0.58	0.21	71700000	718.02	23661.00

Mu 1 = 1 x 10<sup>-7</sup>

F @ r	Δ R Nr ptp	Δ R Nr rms	Δ R N ptp	Δ R N rms	N	Nr	Depth Ft.
101	22.81	8.17	24.10	8.71	40000000	45.50	1320.00
201	7.58	2.73	7.80	2.78	9850000	104.17	3250.50
301	3.95	1.01	4.02	1.01	16400000	169.76	5412.00
501	1.74	0.62	1.74	0.63	30700000	312.88	10131.00
1000	0.58	0.21	0.58	0.21	71200000	718.15	23496.00